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ABSTRACT

The effects of providing immediate knowledge of results (KR) and adaptive testing on test anxiety and test-taking motivation were investigated. Also studied was the accuracy of student perceptions of the difficulty of adaptive and conventional tests administered with or without immediate knowledge of results. Testees were 350 college students divided into high- and low-ability groups and randomly assigned to one of four test strategies by KR conditions. The ability level of examinees was found to be related to their reported levels of motivation and to differences in reported motivation under the different testing conditions. These results suggest that adaptive testing creates a psychological environment for testing which is more equivalently motivating for examinees of all ability levels and results in a greater standardization of the test-taking environment, than does conventional testing. (Author)

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PSYCHOLOGICAL EFFECTS OF IMMEDIATE KNOWLEDGE OF RESULTS AND ADAPTIVE ABILITY TESTING

Nancy E. Betz
and
David J. Weiss

RESEARCH REPORT 76-4
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study investigated the effects of providing immediate knowledge of results (KR) and adaptive testing on test anxiety and test-taking motivation. Also studied was the accuracy of student perceptions of the difficulty of adaptive and conventional tests administered with or without immediate knowledge of results. Testees were 350 college students divided into high- and low-ability groups and randomly assigned to one of four test strategies by KR conditions. The ability level of examinees was found to be related to their reported levels of motivation and to differences in reported motivation under

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the different testing conditions. Low-ability examinees reported significantly higher levels of motivation on the stradaptive test than on the conventional test, while the reported motivation of high-ability examinees did not differ as a function of testing strategies. The effect of knowledge of results on reported motivation also differed as a function of ability level. Low-ability testees reported lower motivation with KR than without KR, while higher ability testees reported higher motivation with KR. Analysis of the anxiety data indicated that students reported significantly higher levels of anxiety on the stradaptive test than on the conventional test. The provision of KR did not result in significant differences in reported anxiety. However, highest levels of anxiety were reported by the low-ability group on the stradaptive test administered with KR. These results in conjunction with previously reported data on effects of KR on ability test performance, were interpreted as being the result of facilitative anxiety. Students were able to perceive the relative difficulty of test items with some accuracy. However, perceptions of the relative degree of test difficulty were much more closely related to actual test score on the conventional test than on the stradaptive test. Over 90% of the students reacted favorably to the provision of immediate KR. These results suggest that adaptive testing creates a psychological environment for testing which is more equivalently motivating for examinees of all ability levels and results in a greater standardization of the test-taking environment, than does conventional testing.

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Psychological Effects of Immediate Knowledge of Results and Adaptive Ability Testing

Computer-assisted testing procedures have made it possible to explore and implement important new approaches to psychological measurement which have not been feasible using the procedures of paper-and-pencil testing. The focus of most research to date on adaptive testing (Weiss & Betz, 1973) or tailored testing (Lord, 1970) has been on its potential to improve the psychometric characteristics of test scores. For example, adaptive and conventional testing strategies have been compared on the basis of such psychometric criteria as parallel-forms reliability (e.g., Betz & Weiss, 1974, 1975), test-retest stability (e.g., Betz & Weiss, 1973, 1975; Larkin & Weiss, 1974; Vale & Weiss, 1975a), information curves (e.g., Lord, 1971a, b; Betz & Weiss, 1974, 1975; Vale & Weiss, 1975b; McBride & Weiss, 1976), and fidelity or "validity" correlations (e.g., Betz & Weiss, 1974, 1975; Vale & Weiss, 1975b; McBride & Weiss, 1976).

There has been little research, however, on the potential of computer-administered testing procedures to improve the psychological environment of ability testing. Constructors and users of ability tests should be concerned not only with the psychometric properties of tests, but also with the psychological effects of those tests on the person being measured, since adverse psychological effects may reduce the usefulness of a given test score. For example, unless people are motivated to do their best on a test, their scores will not reflect their maximum performance capabilities. Individuals may become anxious, discouraged, or frustrated in testing situations; such reactions may interfere with the extent to which test scores reflect those individuals' full capabilities. Thus, testing conditions which elicit high levels of test-taking motivation and minimize the occurrence of interfering responses may be as important as the psychometric properties of the test itself in obtaining accurate measurements of individuals.

The Psychological Environment of Ability Testing

Test difficulty. It has been suggested (e.g., Hansen, Johnson, Fagan, Tam & Dick, 1974; Weiss & Betz, 1973) that adaptive testing procedures should create a more favorable psychological environment for all testees than do conventional, non-adaptive tests. In the typical conventional testing situation, where items are appropriate only for individuals of average ability in a defined group, the experience of test-taking is likely to be quite different for examinees of different ability levels. Low-ability individuals receive items which are often difficult for them and may react by feeling threatened, anxious, or frustrated; the test may seem hopeless and they may simply stop trying. High-ability individuals, on the other hand, receive items which are too easy for them; they may find the task boring and unchallenging and, in a fashion similar to that of the low-ability examinees, may simply stop trying to do their best. It is only for average-ability examinees that items are likely to be sufficiently difficult to be challenging and yet not so difficult as to seem hopeless.

Adaptive testing procedures, on the other hand, tend to maintain an appropriate level of item difficulty for *each* individual, unlike conventional tests which do so only for individuals of average ability. Consequently, the motivation of high-ability testees may be maintained by the degree of challenge presented by items appropriate to their ability levels. Further, and perhaps more important, low-ability testees may experience less anxiety and frustration in an adaptive test than in a conventional test. Consequently, low-ability testees may be encouraged or motivated to do their best when the items presented to them are near the level of their capabilities.

Because adaptive testing requires that subsequent test items be selected on the basis of information derived from analysis of a testee's responses to previous test items, most adaptive testing strategies require computer administration. Only a few adaptive testing strategies--the pyramidal test (Bayroff, Thomas & Anderson, 1960), the two-stage test (e.g., Angoff & Huddleston, 1958), and the flexilevel test (Lord, 1971c)--have been administered in paper-and-pencil mode. However, in the studies in which the pyramidal and flexilevel tests were administered in a paper-and-pencil format (Olivier, 1974; Seeley, Morton & Anderson, 1962), significant numbers of examinees invalidated their test protocols by failing to follow the branching instructions properly. Thus, even adaptive testing strategies which are designed for paper-and-pencil administration can be administered more effectively by interactive computers.

Immediate knowledge of results. Another approach to improving the psychological environment of testing involves telling testees immediately whether each item response was correct or incorrect. Bayroff (1964), Ferguson and Hsu (1971), and others have postulated that immediate knowledge of results has an incentive or motivational effect on examinee performance on ability tests.

While immediate knowledge of results, or KR, can be provided on paper-and-pencil tests (e.g., Locke, Cartledge, & Koeppel, 1968; Annett, 1969), its provision is inefficient and unwieldly at best. The most frequently used KR device, the punchboard developed by Pressey (1950), is awkward to use and requires more effort from examinees who receive KR than from those who do not receive KR. Whether because of the difficulty of providing KR on paper-and-pencil tests or because of the scarcity of research concerning its effects on ability test performance, knowledge of results only rarely has been incorporated into ability testing situations.

The administration of ability tests by computer, on the other hand, allows fast and efficient provision of KR to examinees without requiring additional effort of them. Thus, it is now feasible to investigate the effects of incorporating immediate KR as a standard procedure in ability testing.

Most studies to date on the effects of immediate KR on test performance have used classroom achievement tests in which KR was provided using punchboard devices or specially constructed answer sheets. Consequently, the generalizability of the findings to the situation of computer-administered ability tests and computer-administered KR is subject to question. These studies, reviewed in detail by Betz & Weiss (1976), have yielded conflicting results. Some investigators have reported that KR enhanced test performance,

some that KR led to an increase in errors, and still others that KR conditions have no effect on test scores.

In two studies (Betz, 1975; Sweet & Ringness, 1971) interactions were found between the effects of KR and racial or socioeconomic variables. Sweet and Ringness (1971) concluded that middle-class students, who typically have done relatively well on ability tests, already are highly motivated to do well and do not profit from the additional incentive effects of immediate KR. Lower-class students, or those who typically show relatively poor performance on ability tests, do not tend to be highly motivated in general; consequently, immediate KR may increase their motivation to do well, and in turn, increase their test scores.

An alternative hypothesis concerning the relationship between ability level (or "typical test performance level") and the effects of KR was offered by Betz and Weiss (1976). According to this hypothesis, high-ability students should receive high proportions of positive (i.e., "correct") KR on conventional tests constructed to be most appropriate for the average ability level in the group. Consequently, KR is likely to encourage, and perhaps thus motivate, high-ability examinees. Low-ability examinees, on the other hand, receive mostly negative (i.e., "incorrect") KR and may be discouraged, rather than motivated, when they receive KR. It is possible, therefore, that the quality of KR, or the proportion of positive KR, may be related to the effects of KR on performance and on the examinee's reactions to KR during testing. Thus, in studies of effects of both KR and test difficulty on test performance and behavior, the ability level of the examinee may be important in determining the effects of the testing environment on the psychological reactions of examinees, and should be explicitly incorporated into studies of such effects.

Some investigators (e.g., Ammons, 1956; Ross, 1933) have hypothesized that providing immediate knowledge of results to testees may be unnecessary because they are always receiving some subjective knowledge of results. That is, examinees may have a subjective sense of how well they are performing on an ability test. However, there is little data concerning this hypothesis. In the only study available (Ross, 1933), the correlation between examinees' estimates of their test scores and their actual scores was $r=.71$. This finding is only tangentially relevant to the effects of KR on test performance, however, since the accuracy of testees' estimates of total scores might be substantially different from the accuracy of their perceptions of the difficulty levels of a set of test items.

In summary, while the psychological reactions of examinees to testing situations may affect the accuracy with which tests can measure their abilities, very little is known about those reactions. Further, there is little information concerning either the effects of situational variables on the psychological reactions of examinees or the relationship between the testees' ability level and the extent to which they are psychologically able to demonstrate their full capabilities.

Objectives

The purpose of this study was to investigate the psychological reactions of examinees to a computer-based ability testing environment incorporating both adaptive testing and the provision of immediate knowledge of results. The psychological reactions of examinees were considered important because they can either facilitate or interfere with the extent to which test scores reflect the "maximum performance" capabilities (Cronbach, 1970) of each individual.

Within this broad area of interest, there were three specific purposes of the investigation. Of central interest were the effects of adaptive versus conventional testing and of the provision of immediate knowledge of results on the test-taking motivation and test anxiety of high- and low-ability examinees. In the study reported by Betz and Weiss (1976), both high- and low-ability examinees obtained significantly higher test scores under KR conditions than under no-KR conditions, and low-ability examinees obtained higher scores on an adaptive test than on a conventional test. Thus, it was of interest to determine whether or not the effects of KR and adaptive testing on test performance were accompanied by consistent effects of these variables on motivation and anxiety.

A second purpose of the study was to investigate the nature and accuracy of subjective knowledge of results, or the examinees' perceptions of test difficulty. Subjective KR has been used to explain the absence of effects in studies providing objective KR to examinees, but there is little data to support or reject its existence as an explanatory construct.

Further, the existence of accurate perceptions of test difficulty is basic to the hypothesis that adaptive testing may improve the psychological environment of testing, particularly for examinees for whom conventional ability tests are inappropriate in difficulty level. For example, it is hypothesized that less frustration, discouragement, and anxiety will be induced in low-ability examinees when test items administered are appropriately difficult than when items are far too difficult for them. This hypothesis is based on the assumption that low-ability examinees will accurately *perceive* the difficulties of the test items. Thus, claims for the psychological benefits of adaptive testing necessitate demonstration of the existence of accurate subjective KR.

The final purpose of the study was to investigate examinees' reactions to the provision of immediate KR and the relationship between these reactions and the quality of the KR (i.e., the proportion of KR which was positive). Since immediate KR had been shown to enhance test performance (Betz & Weiss, 1976), data indicating that it also improved the psychological environment of testing might suggest the wider inclusion of immediate knowledge of results into testing procedures.

METHOD

Design

The data were part of a larger study (Betz, 1976; Betz & Weiss, 1976) which was concerned with the effects of immediate knowledge of results and

adaptive versus conventional testing strategies on several aspects of ability test performance and examinee behavior. The design of the study involved computerized administration of either a 50-item conventional ability test or a stradaptive ability test (Weiss, 1973), either with or without immediate knowledge of results, to two groups of subjects.

One group, consisting of students from the College of Liberal Arts at the University of Minnesota, was considered the *High-Ability group* because these individuals typically have performed relatively well on ability and scholastic aptitude tests. The second group, consisting of students from the University's General College, was considered the *Low-Ability group* because their average level of performance on ability and aptitude tests was lower than that of the former group. Within each subject group, students were assigned at random to one of the four treatment conditions (i.e., the conventional or the stradaptive test with or without KR).

The major dependent variables of interest in the present report were the psychological reactions of the examinees. Immediately after taking the experimental test, examinees were asked to respond to several Likert-type questions indicating how motivated they had been, how anxious they had felt, and how difficult the test had seemed to them. From the responses to these questions, scales of overall motivation and overall anxiety were constructed. The questions concerning test difficulty were used to assess the nature and accuracy of examinees' subjective knowledge of results. In addition, those examinees receiving immediate KR were asked to respond to questions concerning their reactions to its provision.

Ability Tests

Item pool. The item pool used to construct the conventional and stradaptive tests of verbal ability consisted of five-alternative multiple-choice vocabulary items. The items were calibrated in samples of college undergraduates, and normal ogive difficulty and discrimination parameters were available for each item. Details concerning the development and calibration of the item pool are reported in McBride and Weiss (1974).

Conventional test. The conventional test consisted of 50 items peaked around the mean ability level of the high-ability group. In terms of the normal ogive item characteristic curve model (Lord & Novick, 1968) the mean difficulty level of the 50 items in the test was b=-.20, and the mean discrimination value was a=.89. Further details concerning the characteristics and scoring of the peaked conventional test may be found in Betz and Weiss (1976, p. 12).

Stradaptive test. In constructing the stradaptive test, the items in the pool were grouped into nine levels, or strata, on the basis of their difficulty. (For details of the construction of the stradaptive test see Betz and Weiss, 1976, p. 10). There was no overlap in item difficulty between adjacent strata, and the difficulty ranges of the items spanned the difficulty continuum from b=-3 to b=+3. Mean difficulties of the strata ranged from $\bar{b}$=-2.67 to $\bar{b}$=2.63. Once items had been grouped into difficulty levels, they were ordered by discriminating power. There were a maximum of 30 items in a stratum, and all items had a minimum discrimination of a=.30 (corresponding to an item-total score biserial correlation of .28).

Examinees began the stradaptive test in a stratum determined from their reported grade-point averages (GPA); those examinees reporting high GPAs began the test with more difficult items than did those reporting lower GPAs. Examinees were branched through the stradaptive item structure according to the rule that following a correct response, the most discriminating item remaining in the next more difficult stratum was administered, and following an incorrect response, the most discriminating item in the next less difficult stratum was administered. Testing was continued in this manner until either a ceiling stratum (see Weiss, 1973, p. 17-20; Betz & Weiss, 1976, p. 10) had been identified or 75 items had been administered.

All-Item ability estimate. In order to study the relationships between psychological reactions to testing and ability level, a single maximum likelihood ability estimate (Betz & Weiss, 1976, p. 11) was calculated from each examinee's responses to the items in the experimental test and to the 44-item post-test administered as the last part of the experimental procedure. The post-test was a conventional computer-administered test constructed using vocabulary items from Educational Testing Service's Cooperative School and College Ability Tests, forms 2A, 2B, 3A, and 3B (see Betz & Weiss, 1976, p. 12, for details of its construction). The items in the post-test, like those in the item pool used for the experimental tests, used a five-alternative multiple-choice format. The post-test was administered without KR. Thus, the All-Item ability estimate was based on all of the item response data available for each individual. It included responses to either the peaked conventional or the stradaptive test, administered with or without KR, and responses to the 44-item post-test.

Psychological Reactions

Since very little research, other than that on state anxiety and test anxiety, has concerned itself with affective reactions toward testing situations, there were few guidelines as to how to assess the psychological effects of testing. Several types of examinee reactions were of interest in the present study: 1) level of reported motivation to do well; 2) level of state anxiety; 3) perceived difficulty of test items and of the test as a whole in relationship to the examinee's ability level (i.e., the presence and accuracy of subjective knowledge of results); and 4) reactions to the provision of KR. Because of the variety of types of information desired from the examinee, it was possible to include only a few questions designed to measure each type of reaction. Questions measuring the various psychological reactions were intermixed and administered immediately following the experimental test, but prior to the post-test.

Motivation. Four items were written to assess level of examinee motivation. Table 1 shows these items and the serial position in which they were administered[1]. Two items, "Did you feel challenged to do as well as you could

[1]In addition to questions concerned with motivation, anxiety, perception of test difficulty and reactions to KR, six additional questions (Items 5, 8, 14, 16, 17, 23) were asked of the testees. These items were primarily concerned with guessing behavior and were not analyzed for this report.

on the test?" and "Did you care how well you did on the test?" reflected a general motivation to do well. The item "How frequently were you careful to select what you thought was the best answer to each question?" was intended to operationalize level of motivation in terms of the behavior of careful versus careless responding. The fourth item "Do you think that you could have done better if you had tried harder?" indicated the extent to which examinees felt they had tried to demonstrate their maximum capabilities.

Table 1
Motivation Items, Serial Position of Administration, and Weights Assigned to Response Alternatives

Item and Response Alternatives	Serial Position	Assigned Weight
How frequently were you careful to select what you thought was the best answer to each question?	6	
1. Almost always		4.0
2. Frequently		3.2
3. Sometimes		2.4
4. Rarely		1.6
5. Never		.8
Do you think that you could have done better on the test if you had tried harder?	9	
1. I definitely could have		.8
2. I probably could have		1.6
3. I'm not sure		2.4
4. I probably couldn't have		3.2
5. I definitely couldn't have		4.0
Did you feel challenged to do as well as you could on the test?	13	
1. Not at all		1
2. Somewhat		2
3. Fairly much so		3
4. Very much so		4
Did you care how well you did on the test?	18	
1. I cared a lot		4.0
2. I cared some		3.2
3. I cared a little		2.4
4. I cared very little		1.6
5. I didn't care at all		.8

Anxiety. Three items were included to assess level of reported anxiety. These items and their response alternatives are shown in Table 2, which also indicates the serial position of each item within the series of reactions items administered. Two of the items, "Were you nervous while taking the test?" and "How did you feel while taking the test?" were patterned after the items used by Hedl (1973) in his five-item version of the A-State Scale from the

State-Trait Anxiety Scale (Spielberger, Gorsuch & Lushene, 1969). The third item, "During testing, did you worry about how well you would do?" is similar to some items used in the Test Anxiety Questionnaire (TAQ; Mandler & Sarason, 1952) and the Test Anxiety Scale (Sarason, 1958), which was derived from items in the TAQ.

Table 2
Anxiety Items, Serial Position, and Weights Assigned to Response Alternatives

Item and Response Alternatives	Serial Position	Assigned Weight
During testing, did you worry about how well you would do?	4	
1. Not at all		1
2. Somewhat		2
3. Fairly much so		3
4. Very much		4
Were you nervous while taking the test?	7	
1. Not at all		1
2. Somewhat		2
3. Moderately so		3
4. Very much so		4
How did you feel while taking the test?	11	
1. Very tense		4
2. Somewhat tense		3.2
3. Neither tense nor relaxed		2.4
4. Somewhat relaxed		1.6
5. Very relaxed		.8

Quantification of motivation and anxiety levels. Motivation and anxiety scales were constructed by combining responses to the individual motivation and anxiety items. In constructing the scales, each of the constitutent items was given equal weight in determining a total score. Accordingly, since the items used either four or five response alternatives, responses to items having five alternatives were reweighted to a scale of 1 to 4. Items also were reweighted so that the response alternative indicating highest level of motivation or most anxiety would receive a weight of 4; alternatives indicating least motivation or anxiety received a weight of 1 for a four-response item, or .8 for a five-response item. Tables 1 and 2 contain the weights assigned to each response alternative in calculating total motivation scores and total anxiety scores, respectively. Total scores were obtained by adding the weights corresponding to the chosen alternative for each of the items in the scale.

Perceived test difficulty. Six items were written to assess the nature and accuracy of perception of test difficulty; these items are shown in Table 3. Four of the items, including "How often did you feel that the questions in the test were too easy for you?" and "In relation to your vocabulary ability, how difficult was the test for you?" reflected examinees' perceptions

of the degree of difficulty of the test questions in relationship to their knowledge or ability. The other two items were concerned with the effects (e.g., frustration) of the perceived difficulty of the test on the testee's performance levels.

Table 3
Perception of Test Difficulty Items
and Serial Position of Administration

Item and Response Alternatives	Serial Position
How often did you feel that the questions in the test were too easy for you?	1
1. Always	
2. Frequently	
3. Sometimes	
4. Seldom	
5. Never	
How often did you feel that the questions in the test were too hard for you?	2
1. Always	
2. Frequently	
3. Sometimes	
4. Seldom	
5. Never	
How often did you feel that the questions in this test were just about right for someone of your ability?	3
1. Always	
2. Frequently	
3. Sometimes	
4. Seldom	
5. Never	
In relation to your vocabulary ability, how difficult was the test for you?	10
1. Much too difficult	
2. Somewhat too difficult	
3. Just about right	
4. Somewhat too easy	
5. Much too easy	
Did you feel frustrated by the difficulty of the test questions?	12
1. Not at all	
2. Somewhat	
3. Fairly much so	
4. Very much so	
How well do you feel you did on this test in comparison to your performance on other tests like this?	15
1. Much better	
2. Somewhat better	
3. About the same	
4. Somewhat worse	
5. Much worse	

Reactions to KR. Those examinees receiving KR were asked to respond to seven items concerning their reactions to its provision; these items are shown in Table 4. In these items, the term "feedback" was used instead of the term

"KR" since it was thought that students would be more familiar with the former term than with the latter. Three items, "Did getting feedback after each question make you nervous?", "Did getting feedback after each question interfere with your ability to concentrate on the test?", and "How did you feel

Table 4
Items Concerning Reactions to the Provision of
KR and Serial Position of Administration

Item and Response Alternatives	Serial Position
Did receiving feedback after each question interfere with your ability to concentrate on the test?	20
1. No, not at all	
2. Yes, somewhat	
3. Yes, moderately so	
4. Yes, very much so	
Did getting feedback after each question make you nervous?	21
1. No, not at all	
2. Yes, somewhat	
3. Yes, moderately so	
4. Yes, very much so	
How did you feel when you found that your answers were incorrect?	25
1. It bothered me a lot	
2. It bothered me some	
3. It bothered me a little	
4. It didn't bother me at all	
Did getting feedback on this test make it more interesting or less interesting?	19
1. Much more interesting	
2. Somewhat more interesting	
3. Didn't make any difference	
4. Somewhat less interesting	
5. Much less interesting	
Did you try harder to get the questions right because you knew you would get feedback after each question?	22
1. No, not at all	
2. Yes, somewhat	
3. Yes, moderately so	
4. Yes, very much so	
Were you interested in knowing whether your answers were right or wrong?	24
1. I was very interested	
2. I was moderately interested	
3. I was somewhat interested	
4. I didn't care at all	
How do you feel about getting feedback?	26
1. I'd rather not know whether my answers were right or wrong	
2. I really don't care whether I get feedback or not	
3. I liked getting the feedback	

when you found that your answers were incorrect?" were included to determine whether providing KR had any potentially disruptive effects on examinee performance. The item "Did you try harder to get the questions right because you

knew you would get feedback after each question?" reflected the relationship between KR and motivation to do well. The other three items, including "Did getting feedback on this test make it more or less interesting?", assessed the extent to which examinees felt that receiving KR had made test-taking a more or less interesting and/or positive experience for them.

Procedures

The data for this study were obtained from the subjects and experimental procedures reported by Betz (1976) and Betz and Weiss (1976). Briefly, each of 350 students (239 High-Ability and 111 Low-Ability) completed a computer-administered experimental ability test, the series of psychological reactions items, and a post-test. The experimental test, assigned at random to students within ability groups, was either a conventional or stradaptive test administered with or without immediate knowledge of results. All students were tested individually at cathode-ray terminals connected to a real-time minicomputer.

Analysis of Data

Data of interest in this study consisted of the following for each examinee: 1) responses to the individual motivation, anxiety, and perception of difficulty items; 2) scores on the composite anxiety and motivation scales; and 3) All-Item maximum likelihood ability estimates. Additional data available for examinees who had received KR included their reactions to the provision of KR and the proportions of positive and negative KR received (obtained from calculation of the percentage of correct responses to the items in the experimental test).

Motivation and anxiety. Mean motivation and anxiety composite scores were analyzed using a "classic experimental" three-way analysis of variance (Nie, Hull, Jenkins, Steinbrenner & Bent, 1975, pp. 405-408). KR, testing strategy and ability level group were the independent variables. The mean and standard deviation of scores within each treatment-subject group combination were calculated, and post-hoc comparisons of sub-group means were made using Scheffé's (1959) method. In addition, product-moment correlations were calculated between composite motivation scores and ability level, as determined by the All-Item ability estimate, and between composite anxiety scores and ability level.

In order to examine students' psychological reactions at the item level, distributions were obtained of the percentages of individuals selecting each response alternative of the motivation and anxiety items, both for the total group of examinees and as a function of KR conditions and testing strategy. Chi-square tests of independence were used to determine whether there were significant relationships between item responses and KR conditions or between item responses and testing strategy.

Perceived test difficulty. The percentage of individuals selecting each response category of the perception of test difficulty items was obtained for the total group and as a function of KR and testing strategy. To determine the accuracy of perceived test difficulty, correlations were computed between scores on each of the six items (using arbitrary 1 through 5 weights) and the All-Item ability estimate. Finally, in order to examine the effects of KR and

testing strategy on accuracy of perceived test difficulty, correlations were calculated between the item responses and the All-Item ability score within the two KR treatment groups and within the groups receiving different experimental tests.

Reactions to the provision of KR. Analysis of reactions to the provision of KR was intended primarily for descriptive purposes, since little is known about how individuals react to it. Accordingly, percentages of examinees selecting each response category and the mean and standard deviation of item scale values were calculated.

Additional analyses were concerned with whether or not the proportion of positive KR influenced the reactions of examinees to its provision. In these analyses the percentage of correct ability test item responses was calculated for each person. Correlations then were calculated between percentage correct and responses to the KR items, assigning arbitrary integer weights to the item responses. The mean and standard deviation of the percentage correct scores were calculated within the conventional and stradaptive test groups to determine the relative percentages of positive KR for the two testing strategies.

RESULTS

Motivation

Mean motivation scores. Table 5 presents the means and standard deviations of the motivation composite scores as a function of Ability group, testing strategy, and KR. Also shown are results of the three-way analysis of variance. There was a significant main effect for Ability group, and there were significant interactions between Ability group and testing strategy, and between Ability group and KR. In general, the High-Ability group reported significantly higher levels of motivation than did the Low-Ability group. This significant group difference reflected the higher levels of motivation for the High-Ability group on both tests, as compared to the high levels of motivation for the Low-Ability group only on the stradaptive test. The mean level of motivation reported by Low-Ability students taking the stradaptive test (12.5) was significantly higher than that reported by Low-Ability students completing a conventional test (11.3). In contrast, the means for High-Ability students taking the stradaptive test (12.4) and the conventional test (12.6) were not significantly different. While High-Ability students reported significantly higher levels of motivation on the conventional test than did Low-Ability students, on the stradaptive test there was no significant difference in reported motivation between the two groups.

The interaction between group and knowledge of results reflected the different reactions of the High- and Low-Ability groups to the provision of KR. In the High-Ability group, mean levels of reported motivation were slightly higher under KR conditions (12.6) than under No-KR conditions (12.3). In the Low-Ability group, motivation was lower under KR conditions (11.5) than under No-KR conditions (12.2). While this latter difference was not statistically significant, it was larger and in the opposite direction than the difference between KR and No-KR conditions in the High-Ability group,

indicating that KR had a different type of influence on the levels of motivation reported by High- and Low-Ability examinees.

Table 5
Means and Standard Deviations of Motivation Scores for Conventional and Stradaptive Tests in High- and Low-Ability Groups With and Without KR

	Experimental Condition						Combined Conditions		
	KR			No-KR					
Test and Group	*N*	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.
Conventional									
High-Ability	60	12.7	1.8	57	12.4	2.3	117	12.6	2.02
Low-Ability	28	11.0	2.1	28	11.5	2.6	56	11.3	2.38
Stradaptive									
High-Ability	60	12.5	2.0	62	12.1	2.2	122	12.4	1.78
Low-Ability	28	12.0	2.8	27	13.0	1.9	55	12.5	2.45
Combined Groups									
Conventional	88	12.2	2.0	85	12.2	2.4	173	12.2	2.2
Stradaptive	88	12.4	2.3	89	12.5	1.7	177	12.4	2.0
High-Ability	120	12.6	1.9	119	12.3	2.4	239	12.5	1.9
Low-Ability	56	11.5	2.5	55	12.2	2.4	111	11.9	2.5
Total	176	12.3	2.1	174	12.3	2.3	350	12.3	2.2

Three-Way Analysis of Variance

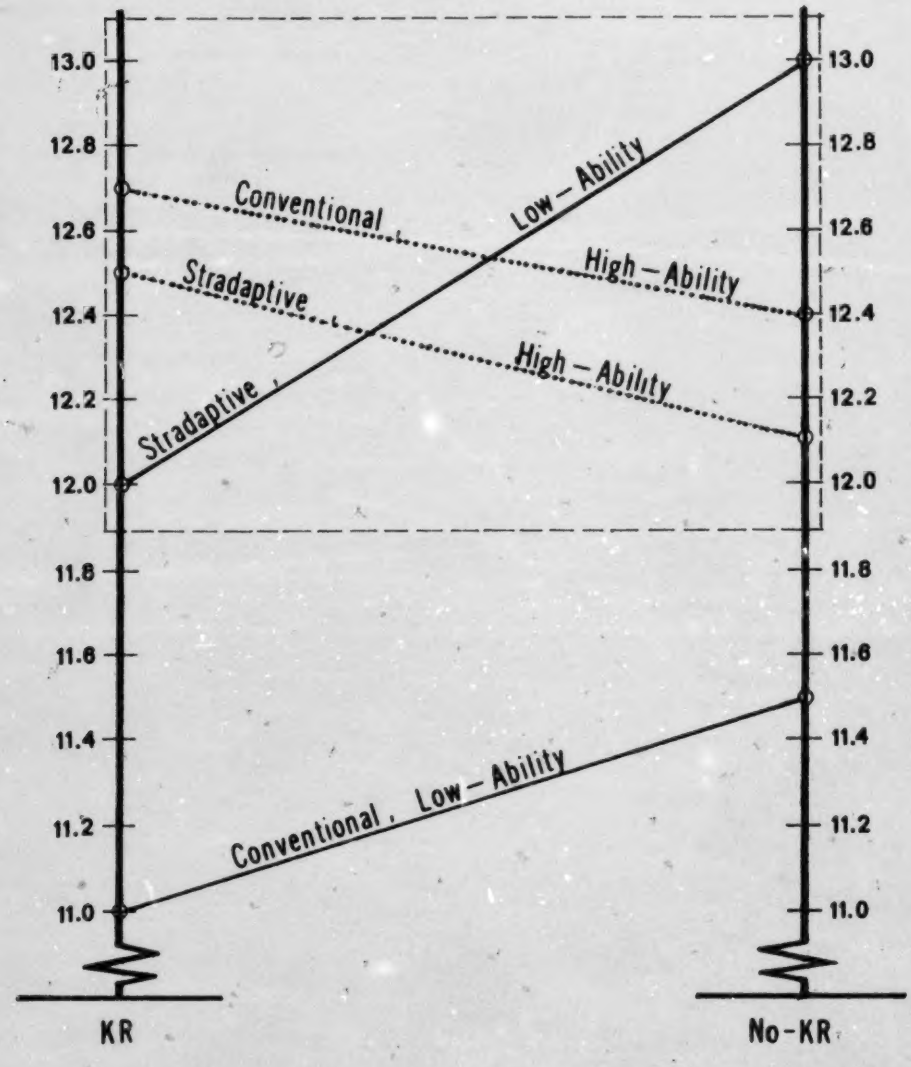
Source of Variation	Sum of Squares	DF	Mean Square	*F*	*p*[a]
Main Effects	38.84	3	12.95	3.01	.030
Ability Group	31.21	1	31.21	7.25	.007
Test	6.91	1	6.91	1.61	.203
KR	.33	1	.33	.08	.999
Two-Way Interactions	52.36	3	17.45	4.05	.008
Ability Group x Test	33.71	1	33.71	7.83	.006
Ability Group x KR	18.04	1	18.04	4.19	.039
Test x KR	.75	1	.75	.17	.999
Three-Way Interaction					
Ability Group x Test x KR	.83	1	.83	.19	.999
Residual	1468.39	341	4.31		
Total	1560.42	348	4.48		

[a]Estimated probability of error in rejecting null hypothesis.

Figure 1 shows the means for the eight experimental groups. The dashed line in Figure 1 encloses subgroup means that were not significantly different from each other. As Figure 1 shows, testing conditions had significant effects on the reported motivation of Low-Ability students. Means for the Low-Ability group who completed the conventional test with KR (11.0) or without KR (11.5)

were significantly different from the means for all other treatment groups. Thus, the Low-Ability group reported significantly lower motivation to perform well when administered a conventional test, with or without KR.

Figure 1
Mean Motivation Scores as a Function
of KR Condition, Testing Strategy, and Ability Group



The data also show that while the High-Ability group reported a higher overall level of motivation than the Low-Ability group, levels of motivation reported by Low-Ability examinees on the stradaptive test under either KR or No-KR conditions were not significantly different from those reported by

High-Ability examinees under any of the four testing conditions. Testing conditions did not have significant effects on the levels of motivation reported by High-Ability examinees; these individuals appear to be highly motivated regardless of conditions.

Responses to motivation items. Table 6 indicates the percentage of examinees selecting each alternative of the four motivation items, as a function of KR, testing strategy and for the total group. In general, it appears that examinees were fairly highly motivated; 57.6% of the total group reported that they almost always had tried to select the best answer to each question. Most (57%) felt that they "definitely" or "probably" could *not* have

Table 6
Response Percentages for Motivation Items as a Function of KR Condition, Testing Strategy, and for Total Group

Item and Response Categories	KR Condition			Testing Strategy			Total Group
	KR	No-KR	p[a]	Conventional	Stradaptive	p[a]	
1. How frequently were you careful to select what you thought was the best answer to each question?			.16			.29	
Almost always	64.1	53.8		60.7	54.5		57.6
Frequently	26.1	34.1		27.2	33.0		30.1
Sometimes	10.8	8.1		8.7	10.2		9.5
Rarely	1.7	2.3		1.7	2.3		2.0
Never	0	1.7		1.7	0		.9
2. Do you think you could have done better on the test if you had tried harder?			.03			.43	
I definitely could have	5.7	4.0		6.4	3.4		4.9
I probably could have	13.6	6.4		12.1	8.0		10.0
I'm not sure	30.7	25.4		27.2	29.0		28.1
I probably couldn't have	35.8	39.9		37.0	38.6		37.8
I definitely couldn't have	14.2	24.3		17.3	21.0		19.2
3. Did you feel challenged to do as well as you could on the test?			.55			.53	
Not at all	4.5	8.1		6.4	6.3		6.3
Somewhat	29.5	27.2		27.7	29.0		28.4
Fairly much so	36.4	37.2		40.5	33.5		37.0
Very much so	29.5	27.2		25.4	31.3		28.4
4. Did you care how well you did on the test?			.52			.46	
I cared a lot	19.9	19.1		18.5	20.5		19.5
I cared some	56.3	50.3		49.7	56.8		53.3
I cared a little	14.8	22.0		21.4	15.3		18.3
I cared very little	6.8	6.9		8.1	5.7		6.9
I didn't care at all	2.3	1.7		2.3	1.7		2.0

Note. Items are numbered 1 to 4 only for purposes of discussion. The order in which items were administered is contained in Table 1. Number of testees in each condition is shown in Table 5.

[a]Probability of error in rejecting null hypothesis of independence, based on chi-square test with four degrees of freedom for items 1, 2, and 4, and three degrees of freedom for item 3.

done better if they had tried harder, and 65% of examinees reported being either fairly much or very much challenged to do their best. Almost three-quarters of the examinees cared "some" or "a lot" about how well they did on the test.

There were significant differences in responses to motivation Item 2 as a function of KR conditions; testees receiving KR were more likely to report that they could have done better if they had tried harder than were those not

Table 7
Means and Standard Deviations of Anxiety Scores for Conventional and Stradaptive Tests in High- and Low-Ability Groups With and Without KR, and Results of the Three-Way ANOVA

Test and Group	Experimental Condition: KR Mean	KR S.D.	No-KR Mean	No-KR S.D.	Combined Conditions Mean	Combined Conditions S.D.
Conventional Test						
High-Ability	5.3	1.7	5.5	1.8	5.4	1.6
Low-Ability	5.4	2.0	6.0	2.4	5.7	2.2
Stradaptive Test						
High-Ability	6.0	2.2	5.8	1.8	6.0	2.0
Low-Ability	6.9	2.5	5.9	2.2	6.4	2.4
Combined Groups						
Conventional Test	5.4	1.8	5.6	1.9	5.5	1.8
Stradaptive Test	6.3	2.4	5.9	1.8	6.1	2.1
High-Ability	5.7	2.0	5.6	1.7	5.7	1.8
Low-Ability	6.2	2.4	5.9	2.3	6.0	2.3
Total	5.8	2.1	5.7	1.9	5.8	2.0

Three-Way Analysis of Variance

Source of Variation	Sum of Squares	DF	Mean Square	*F*	*p*[a]
Main Effects	40.48	3	13.49	3.45	.017
Ability Group	10.64	1	10.64	2.72	.096
Test	29.73	1	29.73	7.61	.006
KR	.62	1	.62	.16	.999
Two-Way Interactions	12.53	3	4.18	1.07	.36
Ability Group x Test	.39	1	.39	.099	.999
Ability Group x KR	1.10	1	1.10	.283	.999
Test x KR	11.12	1	11.12	2.85	.09
Three-Way Interaction					
Ability Group x Test x KR	8.20	1	8.20	2.10	.14
Residual	1332.59	341	3.91		
Total	1393.80	348	4.01		

Note. Subgroup *N*s are shown in Table 5.

[a]Estimated probability of error in rejecting null hypothesis.

receiving KR. However, examinees with KR also reported more often than those without KR that they had tried to select the best answer to each question, although this tendency was not statistically significant.

There were no significant differences in response percentages as a function of testing strategy. Examinees taking the conventional and stradaptive tests were approximately equally likely to report that they had tried to select the best answer to each question, that they felt challenged to do their best on the test, that they couldn't have done better if they had tried harder, and that they cared how well they did on the test.

Motivation and ability level. There was a statistically significant (p=.001) correlation of r=.21 between overall motivation score and ability level measured using the All-Item ability estimate. Thus, it appears that higher overall performance and higher motivation are associated, although the amount of variance in common is low. All four individual motivation items were significantly related to ability level at or below the .05 level of statistical significance. The higher the ability levels of examinees, the more likely they were to 1) report trying to select the best answer to each question, 2) say that they couldn't have done better if they had tried harder, 3) report being challenged to do as well as possible, and 4) care how well they did on the test.

Anxiety

Mean anxiety scores. Table 7 shows the results of the three-way analysis of mean anxiety scores as a function of KR, test, and subject group, and the means and standard deviations of anxiety scores for each experimental subgroup combination. Figure 2 provides a plot of the eight subgroup means.

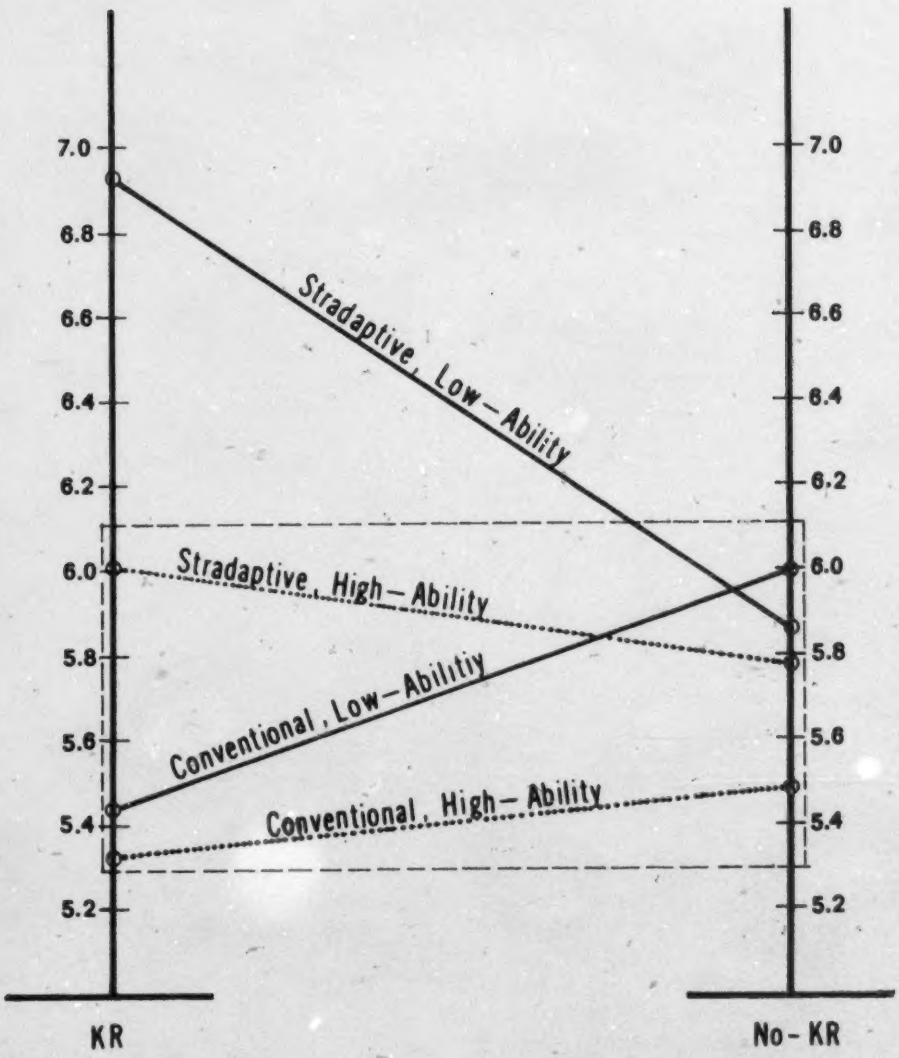
As shown in Table 7, the only significant main effect was for testing strategy; the overall level of anxiety reported by individuals taking the stradaptive test (6.1) was significantly greater than that reported by individuals taking the conventional test (5.5). The main effect of KR was not statistically significant; the mean anxiety scores of examinees tested under KR (5.8) and No-KR (5.7) conditions were similar. However, the interaction between test and KR approached statistical significance (p<.10). Examinees reported more anxiety on the stradaptive test with KR (6.3) than without KR (5.9) but reported more anxiety on the conventional test without KR (5.6) than with KR (5.4). With KR, the difference between the stradaptive test mean of 6.3 and conventional test mean of 5.4 was statistically significant, while without KR the difference (5.9 vs. 5.6) was not significant.

The main effect for Ability Group also approached statistical significance (p<.10). The mean level of reported anxiety for Low-Ability students over all conditions (6.0) was slightly higher than that for High-Ability students over all conditions (5.7). This difference, however, was due primarily to the significantly higher mean level of anxiety (6.9) reported by Low-Ability students taking the stradaptive test with KR, as shown in Figure 2. As Figure 2 also shows, difference among the means for the remaining seven experimental subgroups were not statistically significant.

Responses to anxiety items. Table 8 shows the percentage of examinees endorsing each alternative of the three anxiety items as a function of KR conditions, testing strategy and for the total group. In general, the total group of students did not report experiencing much anxiety during testing. The modal responses to the three questions indicated that they worried about how well they would do but did not feel particularly nervous or tense.

There were no significant differences in reported anxiety as a function of KR; if any trend at all is present it is in the third item, where testees receiving KR report feeling tense or somewhat tense more often than do those not receiving KR.

Figure 2
Mean Anxiety Scores as a Function of KR Condition,
Testing Strategy, and Ability Group



However, there were differences in response percentages as a function of testing strategy. Examinees taking the stradaptive test were more likely to

report feeling moderately or somewhat nervous while taking the test (p=.02), to report worrying about how well they would do (p=.08), and to report being tense, rather than relaxed, while taking the test (p=.13) than were examinees taking the conventional test.

Table 8
Response Percentages for Anxiety Items as a Function of KR Condition, Testing Strategy, and for Total Group

Item and Response Categories	KR Condition			Testing Strategy			Total Group
	KR	No-KR	p[a]	Conventional	Stradaptive	p[a]	
1. During testing did you worry about how well you would do?			.66			.08	
Not at all	21.6	16.8		21.4	17.0		19.2
Somewhat	53.4	54.3		57.8	50.0		53.9
Fairly much	14.8	16.8		11.6	19.9		15.8
Very much	10.2	12.1		9.2	13.1		11.2
2. Were you nervous while taking the test?			.56			.02	
Not at all	59.1	65.3		68.8	55.7		62.2
Somewhat	28.4	25.4		23.7	30.1		26.9
Moderately so	9.1	7.5		4.6	11.9		8.3
Very much so	3.4	1.7		2.9	2.3		2.6
3. How did you feel while taking the test?			.15			.13	
Very tense	3.4	1.2		.6	4.0		2.3
Somewhat tense	22.7	16.2		17.9	21.0		19.5
Neither tense nor relaxed	28.4	38.7		31.8	35.2		33.5
Somewhat relaxed	28.4	27.2		31.2	24.4		27.8
Very relaxed	17.0	16.8		18.5	15.3		16.9

Note. Items are numbered 1 to 3 only for purposes of discussion. The order in which items were administered is contained in Table 2. Number of testees in each condition is shown in Table 5.

[a]Probability of error in rejecting null hypothesis of independence, based on chi-square test with three degrees of freedom for item 1 and four degrees of freedom for items 2 and 3.

Anxiety and ability level. The correlation between the all-item ability estimate and composite anxiety score was -.10. This value of r was significant at p=.04. Responses to only one anxiety item showed a significant (p=.005) relationship to ability level: High-Ability examinees were less likely to report worrying during testing than were low ability examinees. The slight negative correlation between ability level and reported anxiety is in agreement with the tendency for the Low-Ability group to report somewhat higher levels of anxiety than the High-Ability group.

Perceived Test Difficulty

Responses to test difficulty items. Table 9 presents the percentage of examinees selecting each response category of the six items used to measure perceived difficulty of the test taken. Results for the total group can be summarized as follows: 1) examinees in general felt that the experimental ability test items were "seldom" too easy, were "frequently" too hard, and were "sometimes" just about right for their ability level; 2) most examinees felt that, as a whole, the experimental test was "somewhat" too difficult for them; 3) they reported being "somewhat" frustrated by the difficulty of the test

Table 9
Response Percentages for Subjective Knowledge of Results Items as a Function of KR Condition, Testing Strategy, and for Total Group

Item and Response Categories	KR Condition			Testing Strategy			Total Group
	KR	No-KR	p^a	Conventional	Stradaptive	p^a	
1. How often did you feel that the questions in the test were too easy for you?			.03			.34	
Always	0	1.2		1.2	0		.6
Frequently	5.7	2.3		5.2	2.8		4.0
Sometimes	36.9	30.6		32.9	34.7		33.8
Seldom	50.6	51.4		48.6	53.1		51.0
Never	6.8	14.5		12.1	9.1		10.6
2. How often did you feel that the questions in the test were too difficult for you?			.32			.40	
Always	4.0	5.2		5.8	3.4		4.6
Frequently	46.0	53.8		48.0	51.7		49.9
Sometimes	36.4	33.5		32.9	36.9		35.0
Seldom	11.9	6.4		11.6	6.8		9.2
Never	1.7	1.2		1.7	1.1		1.4
3. How often did you feel that the questions in this test were just about right for someome of your ability?			.07			.56	
Always	4.5	1.7		4.0	2.3		3.2
Frequently	30.1	22.0		26.0	26.1		26.1
Sometimes	50.6	52.6		49.1	54.0		51.6
Seldom	13.1	19.7		16.8	15.9		16.3
Never	1.7	4.0		4.0	1.7		2.9
4. In relation to your vocabulary ability, how difficult was this test for you?			.001			.08	
Much too difficult	5.1	15.0		12.7	7.4		10.0
Somewhat too difficult	58.0	62.4		54.9	65.3		60.2
Just about right	31.8	20.2		26.6	25.6		26.1
Somewhat too easy	5.1	1.7		5.2	1.7		3.4
Much too easy	0	.6		.6	0		.3
5. Did you feel frustrated by the difficulty of the test questions?			.09			.70	
Not at all	34.7	26.0		31.8	29.0		30.4
Somewhat	54.5	56.1		56.1	54.5		55.3
Fairly much so	9.7	13.9		9.8	13.6		11.7
Very much so	1.1	4.0		2.3	2.8		2.6
6. How well do you feel you did on this test in comparison to your performance on other tests like this?			.13			.08	
Much better	1.1	0		.6	.6		.6
Somewhat better	12.5	6.4		12.7	6.3		9.5
About the same	51.1	59.4		57.8	52.3		55.0
Somewhat worse	29.5	27.2		22.5	34.1		28.4
Much worse	5.7	7.5		6.4	6.8		6.6

Note. Items are numbered 1 to 6 only for purposes of discussion. The order in which items were administered is contained in Table 3. Number of testees in each condition is shown in Table 5.

[a]Probability of error in rejecting null hypothesis of independence, based on chi-square test with four degrees of freedom for items 1 thru 4 and 6, and three degrees of freedom for item 5.

questions; and 4) they felt that their performance on this test was comparable to that on other similar tests. In general, then, the test was perceived as somewhat too hard and somewhat frustrating.

However, when KR was taken into account there was a significant relationship between perception of difficulty and knowledge of results. Examinees with KR were more likely to consider the questions too easy "frequently" or "sometimes" (Item 1) and were more likely to consider the difficulty of the test as a whole "just about right" for their ability level (Item 4). In addition, on Item 3 examinees with KR showed a marginally significant (p=.07) tendency to consider the individual items more appropriate for their ability levels and on Item 5 a tendency (p=.09) to report less frustration with the difficulty of the test questions. These four items suggest that examinees receiving KR perceived the test as a less difficult and frustrating experience than did those not receiving KR.

Although there were no significant (p<.05) differences as a function of testing strategy, examinees taking the stradaptive test were somewhat more likely to report that the test as a whole was too difficult for them (Item 4, p=.08) and that their performance on the test was "somewhat worse" than their usual levels of performance on such tests (Item 6, p=.08).

Accuracy of perceived test difficulty. Table 10 shows the correlations between responses to the items measuring perceived test difficulty and the All-Item ability estimate for the total group, and as a function of both KR and testing strategy. Each of the six items showed a moderate relationship to ability level for the total group; the values of r for the total group all were significantly different from zero at p<.002.

Table 10
Correlations Between Items Measuring
Perceived Test Difficulty and Ability Level as
a Function of KR Condition, Testing Strategy, and for Total Group

Item[a]	KR Condition		Testing Strategy		Total Group
	KR (N=176)	No-KR (N=174)	Conventional (N=173)	Stradaptive (N=177)	(N=350)
1	-.42	-.35	-.58	-.19	-.39
2	.55	.40	.64	.33	.48
3	-.31	-.32	-.44	-.21	-.33
4	.52	.42	.68	.25	.47
5	-.24	-.29	-.47	-.11	-.28
6	-.23	-.08	-.34	-.00	-.16

Note. For a sample size of 173, differences greater than or equal to r=.22 between Z-transformed values of r are significant at p<.05, while differences greater than or equal to r=.33 are significant at p<.01.

[a]Items are shown in Table 3.

The higher the ability of the examinees, the more likely they were to report that both individual items and the whole test were too easy and that the items were appropriate to their ability levels. Higher ability examinees

also felt better about their levels of performance on the test in comparison to their performance on similar tests. Low-Ability examinees were more likely to report that the test items were too hard and that they had been frustrated by the difficulty of the test. Thus, Low-Ability examinees in general reported the test to be a difficult, inappropriate, and frustrating experience.

A comparison of these correlations within the KR and No-KR groups shows that they are similar to each other in the direction of relationship. All values of r in the No-KR group, except that for Item 6, were significant at $p<.001$. The correlations under KR conditions were generally higher in absolute value than were those under No-KR conditions, thus indicating somewhat more accurate perceptions of item difficulty for examinees receiving KR. But in no case was the difference between the KR and No-KR correlations for a given item statistically significant. Thus, it is evident that examinees not receiving objective KR still were receiving moderately accurate subjective KR.

All of the correlations within the conventional test group were significant at $p<.001$, as were those for all but item 5 and 6 within the stradaptive test group. The correlations for the conventional test group were uniformly and significantly higher than were those for the stradaptive test group. This indicates that students taking a conventional test were perceiving the degree of item difficulty in relationship to their ability level more accurately than were students taking the stradaptive test.

The less accurate perceptions of the relative degree of item difficulty in the stradaptive test group are consistent with what would be expected given the adaptive process of item selection. That is, higher ability examinees were administered relatively difficult items, while lower ability individuals received relatively easy items. Thus the tendency for high ability examinees to rate items as relatively easy and for low ability examinees to rate them as relatively difficult was reduced substantially from that found in the conventional test.

Reactions to the Provision of Knowledge of Results

Responses to KR items. Table 11 summarizes the responses of the total group receiving KR to the items concerning their reactions to the provision of KR. There were no significant differences in these responses as a function of testing strategy. In general, responses were highly favorable. The modal responses indicated that KR: 1) made the test "much more interesting"; 2) interfered "not at all" with testees' ability to concentrate on the test; 3) did "not at all" make them nervous; and 4) caused them to try "somewhat" harder to get test questions correct. Examinees also indicated that they were bothered somewhat when their answers were incorrect, that they were "very interested" in knowing whether their answers were right or wrong, and that they liked getting KR. Thus, examinee reactions indicated that receiving KR made the test a more positive and interesting experience and that for most examinees KR did not have the adverse effects of making them nervous or of interfering with their ability to concentrate.

Percentages of positive and negative KR. Table 12 shows the correlations between the percentage of correct responses (and therefore the percentage of positive KR) and reactions to the provision of KR. Four of the obtained correlations, while small in magnitude, were significantly different from zero.

Table 11

Response Percentages to Items Concerning Reactions to the Provision of KR

	Item and Response Category	*N*	%	Mean	S.D.
1.	Did getting feedback on this test make it more or less interesting?			3.71	.57
	Much more interesting	128	72.7		
	Somewhat more interesting	38	21.6		
	Didn't make any difference	6	3.4		
	Somewhat less interesting	2	1.1		
	Much less interesting	2	1.1		
2.	Did receiving feedback interfere with your ability to concentrate?			3.77	.55
	No, not at all	145	82.4		
	Yes, somewhat	24	13.6		
	Yes, moderately so	5	2.8		
	Yes, very much so	2	1.1		
3.	Did getting feedback make you nervous?			3.7	.59
	No, not at all	128	72.7		
	Yes, somewhat	40	22.7		
	Yes, moderately so	5	2.8		
	Yes, very much so	2	1.1		
4.	Did you try harder to get the question right because you knew you would get feedback?			2.4	1.04
	No, not at all	32	18.8		
	Yes, somewhat	71	41.8		
	Yes, moderately so	29	17.1		
	Yes, very much so	38	22.4		
5.	How did you feel when your answers were incorrect?			2.4	.83
	It bothered me a lot	25	14.8		
	It bothered me some	63	37.3		
	It bothered me a little	69	40.8		
	It didn't bother me at all	12	7.1		
6.	Were you interested in knowing whether your answers were right or wrong?			3.7	.59
	I was very interested	132	75.9		
	I was moderately interested	32	18.4		
	I was somewhat interested	9	5.2		
	I didn't care at all	1	.6		
7.	How do you feel about getting feedback?			3.8	.67
	I'd rather not	10	5.8		
	I really don't care	8	4.6		
	I liked getting feedback	155	89.6		

Note. Items are numbered 1 to 7 only for purposes of discussion. The order in which the items were administered is shown in Table 4.

Examinees receiving greater proportions of positive KR were more likely to indicate that KR made the test more interesting (Item 1) and did not interfere with their ability to concentrate on the test (Item 2). These examinees also indicated more interest in knowing whether their answers were right or wrong (Item 5) and were more likely to say that they liked getting KR (Item 7). There was no relationship between percentage of positive KR and the extent to which KR was reported to make examinees nervous, to cause them to try harder to get questions right, or to bother them when answers were incorrect.

Table 12
Correlations Between Responses to KR Items and Percentage of Positive KR Received

Item	r
1	-.18**
2	-.17*
3	0.00
4	-.01
5	-.20**
6	.06
7	.14*

*Value of r significantly different from zero ($p<.05$)
**Value of r significantly different from zero ($p<.01$)

In order to determine if the quality of KR, whether computer-administered or subjectively perceived, differed between the conventional and stradaptive test, characteristics of the distributions of percentage correct scores within the two tests were examined. The mean percentage correct on the conventional test was .53, and that on the stradaptive test was .49. On both tests, then, KR was generally about half positive and half negative.

However, there was more variability among people in the quality of KR on the conventional test. The standard deviation of percentage correct scores on the conventional test was .20. In contrast, the standard deviation of percentage correct scores on the stradaptive test was .08. Thus, the quality of KR on the stradaptive test was more constant across individuals than it was on the conventional test.

SUMMARY AND CONCLUSIONS

The results of this study indicate that both adaptive testing and the provision of immediate knowledge of results have significant effects on the psychological reactions of examinees to testing conditions. The ability level of testees was found to be related to their general reactions to testing. Ability level also moderated the effects of testing conditions on their psychological reactions.

Motivation

In the total group of subjects, the correlation between reported motivation and the All-Item ability estimate was $r=.21$; this value, while indicating a relatively small degree of relationship, was significantly different from zero. In addition, results from the analysis of variance of motivation scores indicated a significant main effect for Ability Group, with the High-Ability group reporting higher levels of motivation than the Low-Ability group.

While High-Ability examinees generally reported higher levels of test-taking motivation than did Low-Ability examinees, this difference was moderated, and in some cases eliminated, by the differential impact of testing conditions on levels of reported motivation in the two groups. Specifically, testing conditions were found to have significant effects on the reported motivation of Low-Ability students but not on the motivation of High-Ability students.

High-Ability examinees reported high levels of motivation on both the conventional and stradaptive tests, and with KR and without KR. Low-Ability examinees, on the other hand, reported significantly higher levels of motivation on the stradaptive test than on the conventional test, although their levels of motivation did not differ as a function of KR conditions. Thus, while on the conventional test levels of motivation reported by High-Ability examinees were significantly greater than were those reported by Low-Ability examinees, on the stradaptive test the levels of motivation reported by the Low-Ability examinees were equal to or greater than those reported by the High-Ability group.

These results indicate, therefore, that adaptive testing increases the motivation of low-ability examinees, and consequently, their levels of motivation are comparable to those of high-ability examinees. The incentive effects of adaptive testing in the Low-Ability group also were reflected in their levels of test performance. Results reported previously (Betz & Weiss, 1976) indicated that low-ability examinees obtained higher average scores on the stradaptive than on the conventional test.

The findings that high-ability examinees were highly motivated regardless of testing conditions, while the motivation of low-ability examinees was significantly higher under certain conditions of test administration than under others are consistent with the hypotheses of Samuda (1975), Sweet and Ringness (1971), and others. These writers hypothesized that the inferior levels of performance of either lower-class or black individuals--in general, individuals who typically have not performed well on ability tests--may be due partially to lower levels of motivation. The results of the present study when considered in conjunction with those of Betz & Weiss (1976) indicate that adaptive testing can significantly increase the motivation of "low-ability" examinees and that the increased motivation is accompanied by significant increases in ability test scores.

Anxiety

Significantly higher levels of anxiety were reported on the stradaptive test than on the conventional test. Examinees taking the stradaptive test were

more likely to report that they worried about how well they would do and that they were nervous and tense while taking the test than were examinees taking the conventional test. While there were no overall mean differences in anxiety as a function of KR conditions, more anxiety was reported on the stradaptive test, but less on the conventional test, when KR was provided. In both subject groups, the highest level of anxiety occurred in the stradaptive-KR condition, while the lowest level occurred in the conventional-KR condition.

Interestingly, the condition which led to the most anxiety in Low-Ability examinees was also the condition leading to the highest levels of performance (Betz & Weiss, 1976) and high levels of motivation. Thus, adaptive testing in combination with the provision of knowledge of results increased test scores and motivation, but also led to a significant increase in reported anxiety.

These results contradict the research evidence showing a negative relationship between anxiety and test performance (e.g., Sarason, 1958, 1960, 1972; Wine, 1971). However, one possible explanation of these results may be found in the construct of facilitating anxiety, first postulated by Mandler and Sarason (1952). Mandler and Sarason theorized that anxiety has detrimental effects on performance only for individuals who have learned to respond to anxiety with a class of behaviors which interfere with performance; for such individuals, anxiety is "debilitating". For other individuals anxiety is "facilitating" because it elicits task-relevant responses. That is, an increase in the number of task-relevant responses may facilitate performance on the task.

While debilitating and facilitating anxiety are postulated to be individual differences variables dependent on the individual's social learning history, it is possible that testing conditions may affect the extent to which "task-relevant" responses, as opposed to "interfering" responses, are elicited. Wine (1971) reviews research which indicates that situational conditions affect the extent to which "task-relevant" versus "self-relevant" responses are elicited; "self-relevant" or "self-focusing" responses are similar in effect to Mandler and Sarason's "interfering" responses.

Although the results indicated that anxiety may have facilitated the performance of Low-Ability examinees taking the stradaptive test with KR, facilitating anxiety does not appear to be a general moderator of the effects of KR (or other testing conditions) on test performance. For High-Ability examinees, test scores increased with KR, but levels of anxiety did not differ significantly as a function of KR conditions. For Low-Ability examinees administered the conventional test, higher test scores but lower anxiety levels were observed under KR conditions (see Betz & Weiss, 1976).

As was the case with levels of motivation, the levels of anxiety reported by Low-Ability students were more influenced by modifications in testing conditions than were those of High-Ability students. For the High-Ability group, the difference between the mean anxiety scores from the most anxiety-producing situations (stradaptive-KR) to the least (conventional-KR) was .63. In the Low-Ability group, the mean difference corresponding to the same testing situations was 1.47, a difference more than twice as large.

The findings that KR conditions did not have significant effects on anxiety are in contrast with those of Angell (1949), Bierbaum (1965), and Strang and Rust (1973) that examinees receiving KR reported more anxiety than did those not receiving KR. However, in these three studies, KR was provided via Pressey-punchboard devices or specially constructed answer sheets which required more effort from examinees receiving KR. Also, examinees in the studies of Angell and Bierbaum were required to continue responding until they found the correct answer; this procedure could have contributed to the increased nervousness reported by examinees receiving KR. Finally, the dependent variable in all three studies was performance on a classroom achievement test. Since the test scores of examinees were used to determine their course grades, receiving knowledge of incorrect answers may have increased the stress of the situation.

In the present study, the provision of knowledge of results on a computer terminal did not require additional effort from the examinees, and the KR was given immediately following the first response to an item. Thus, within a computer-based testing environment, providing knowledge of results to examinees was found to lead to significantly higher levels of test performance (Betz & Weiss, 1976) without increasing levels of debilitating anxiety in the testing situation.

Perception of Test Difficulty

Results indicated that examinees in general reported the experimental test (i.e., either the conventional or the stradaptive test administered with or without KR) to be a rather difficult and frustrating experience. They were more likely to consider test items as too difficult for them than too easy for them and felt that the experimental test as a whole was too difficult for someone of their own ability level.

Reactions to four of the six "perception of difficulty" items varied significantly as a function of KR conditions; examinees receiving KR perceived the test as a somewhat less difficult and frustrating experience than did examinees not receiving KR. In addition, there was some tendency for examinees taking the stradaptive test to perceive the test as more difficult for them and to perceive that they had done comparatively less well on the test than did examinees taking the conventional test. This latter finding, however, is not surprising considering the fact that about two-thirds of the sample consisted of "high-ability" students. These students probably are accustomed to doing relatively well on ability tests, and an adaptive test is designed to be relatively more difficult for such examinees than is a conventional test.

Results also indicated that examinees' perceptions of the difficulty of the test in relationship to their ability level were moderately accurate whether or not they received computer-administered KR. That is, the students' subjective knowledge of results corresponded somewhat to their actual levels of performance on the test. For the total group of examinees, the absolute value of the correlations between ability level and responses to the four questions dealing specifically with the difficulty of the test items ranged from .33 to .48. Thus, examinees who did relatively well on the test perceived the items as easier for them than did examinees who performed less well.

Further, while the perceptions of examinees who received KR were slightly more accurate than were those of examinees who did not receive KR, in no case was there a statistically significant difference between the correlations of perception of difficulty and ability level in the KR and No-KR groups. In the former group, the absolute values of the four correlations ranged from .31 to .55, while in the latter group the values ranged between .32 and .42.

These results support the hypotheses of Ammons (1956) and Ross (1933) that examinees always are receiving some subjective knowledge of results. That is, examinees do have some idea about how well they are doing on a test whether or not they are given KR. Ross posited the existence of subjective KR in order to explain the absence of effects in a study in which KR was provided to examinees, but the results of the present study indicate that computer-administered KR can increase test scores even though examinees are receiving moderately accurate subjective KR.

Differences in the extent of the relationships between ability level and perception of test difficulty on the conventional and stradaptive tests corresponded to those expected, given the differences between the two tests in the method of selecting the items to be administered to a given individual. On the conventional test, all examinees were administered a series of 50 items selected to be most appropriate for individuals of average ability level. Consequently, most items were expected to be too easy for high-ability students and too difficult for low-ability students. The absolute values of the correlations between ability level and responses to the perception of difficulty items in the conventional test group ranged from .44 to .68. These values are similar to the correlation of .71 found between students' estimates of their scores and their actual scores in the study of Ross (1933).

The stradaptive testing strategy, on the other hand, is designed to select for administration the items which are most appropriate or closest to each testee's ability level. High-ability examinees are administered relatively difficult items, while low-ability examinees receive relatively easy items. In the stradaptive test each examinee, regardless of ability level, converges on items with difficulties such that there is a 50% chance of correctly answering each of the items. While this ideal can only be approximated, the perceptions of examinees about how well they are doing on the test should not be as closely related to their ability levels as they are on a conventional test.

The absolute values of the correlations between ability level and responses to the test difficulty items in the stradaptive group ranged from .19 to .33. These values all were significantly lower than the corresponding values in the conventional test group. While there was still some relationship between ability level and perception of performing well on the test, this relationship was far less pronounced than that found in the conventional test group.

These results are consistent with the hypothesis that adaptive testing, as compared to conventional testing, has an incentive effect for low-ability examinees. If the results from the present study of conventional testing may be generalized to the situation of most group-administered ability and aptitude tests, it is evident that low-ability individuals usually perceive themselves as doing relatively poorly on the test, whereas high ability examinees perceive

themselves as doing well. On an adaptive test, however, the relatively low correlation between ability level and a testee's perception of the difficulty of the test indicated that Low-Ability examinees were perceiving themselves as doing only slightly less well than were High-Ability examinees. Thus, it may be assumed that the subjective KR received by Low-Ability examinees probably was more encouraging than that which they had been accustomed to receiving on conventional ability tests. Such feelings of encouragement may have contributed to the higher test scores obtained by Low-Ability examinees taking the stradaptive test (Betz & Weiss, 1976).

Reactions to the Provision of KR

Reactions to the provision of knowledge of results generally were highly favorable. Most examinees reported that receiving KR made the test a more interesting experience and that they tried harder to do their best when they received KR. Few examinees reported that receiving KR made them nervous or interfered with their ability to concentrate on the test. The only possibly negative effect of providing KR was that most testees reported being somewhat bothered when they found that their answers were incorrect. However, given the relative degree of accuracy of subjective knowledge of results even for examinees who did not receive KR, it is likely that examinees in both KR and No-KR conditions may have been somewhat discouraged when either perceiving or being told that they had answered an item incorrectly.

In general, then, KR was evaluated favorably by the examinees, and it did not elicit adverse reactions which might have interfered with test performance. Overall, 90% of examinees liked receiving knowledge of results, and only 10% either did not like receiving KR or did not care whether they received it or not. These results correspond to those of Pressey (1950), who found that students reported that they liked receiving KR.

As might be expected, there was some relationship between the quality of the KR received and the extent to which students evaluated KR favorably. Students who received higher percentages of positive KR were more likely to evaluate it favorably; small but significant correlations were found between the percentage of positive KR and responses to several of the KR items. Examinees receiving higher proportions of positive KR were somewhat more likely to report that they liked getting KR, that it made the test more interesting, that they were interested in knowing whether their answers were correct or incorrect, and that KR did not interfere with their ability to concentrate on the test.

General Levels of Motivation and Anxiety

Additional findings of the study concerned general levels of test-taking motivation and test anxiety. In general, this group of college students reported relatively high levels of motivation. Most examinees (88%) reported that they either frequently or almost always had tried to select the best answer to each question, and 65% reported that they were either fairly much or very much challenged to do their best on the test. Only about 14% thought that they could have done better if they had tried harder, and only 2% said that they didn't care how well they did on the test. Responses to only one item differed as a function of KR conditions; examinees receiving KR were more likely to

report that they could have done better if they had tried harder. However, given the small percentage of individuals overall who selected this response alternative (14%), reasons for the difference are not immediately apparent.

While most examinees reported being motivated, students in general reported little anxiety in the testing situation. Modal item responses indicated that examinees worried somewhat about how well they would perform but did not feel particularly nervous or tense. The relative absence of feelings of nervousness or tension probably was due to the fact that test scores were not used to determine course grades or to make any other decisions about the individual. There were no significant differences in responses to specific anxiety items as a function of KR conditions.

Limits of Generalizability

The results of the present study of the psychological effects of computer-assisted ability testing should be interpreted with caution for several reasons. First, with the exception of the research on test anxiety and state anxiety in testing situations, very little research effort has been directed at investigating the reactions of examinees to testing situations. For example, there was little previous research to provide guidelines about how to assess examinee motivation, subjectively perceived test difficulty, or reactions to the provision of KR. Accordingly, the items written for use in the present study must be regarded as a first attempt to assess a variety of examinee reactions to testing, and to assess psychological reactions to testing procedures.

Second, because of the variety of reactions assessed, it was possible to include only a few items for each area of interest. As a result, the motivation and anxiety scales were based on responses to only four and three items, respectively. More confidence could be placed in the results of future studies of the effects of KR on motivation and anxiety if such studies used scales that were based on responses to more than three or four items and that had been demonstrated to have adequate psychometric properties, e.g., internal consistency reliability. An obvious way to approach this problem is to use adaptive testing techniques, which permit the measurement of a large number of dependent variables in a minimum of testing time.

It also should be realized that examinees may try to please the experimenter by responding in what they think would be the desired direction. However, this is a problem in all research of this type, and it would seem reasonable that if this tendency were present, it would have equal effect across experimental conditions. Thus, while total group descriptive data may be biased, any treatment differences found most likely would be a function of real differences in reactions. Furthermore, total group data concerning motivation, anxiety and the other dependent variables from this study may provide a baseline for further studies of situational interventions in testing situations in similarly constituted populations and may be useful in comparative studies across populations.

Finally, the results of this study and the previous study (Betz & Weiss, 1976) are not presently generalizable beyond the college population used. Further research of this type in groups of high school students and in other populations would add considerably to the generalizability and potential utility of the present findings.

Conclusions

The present study indicated that levels of test-taking motivation reported by low-ability examinees were significantly higher when they were administered an adaptive, rather than a conventional, test. High-ability examinees reported high levels of motivation regardless of testing conditions.

Adaptive testing, therefore, appears to increase the extent to which *all* examinees, rather than only high-ability examinees, are motivated to do well on an ability test. The use of adaptive tests appears to result in comparable levels of motivation in examinees differing in ability level. Since the increased test-taking motivation of low-ability examinees taking the stradaptive test was accompanied by increases in mean test scores within this group, it may be concluded that adaptive testing creates conditions more conducive to allowing each individual to demonstrate his or her fullest capabilities in test performance.

Significantly more anxiety was reported on the adaptive test than on the conventional test. But the conditions leading to highest reported levels of anxiety in the low-ability group (i.e., stradaptive with KR) were also the conditions under which they obtained the highest test scores and reported high levels of motivation. The construct of facilitative anxiety was offered as a possible explanation for this constellation of findings.

Examinees, in general, had reasonably accurate perceptions of how well they were performing on the test whether or not they received KR. However, perceptions of the relative degree of difficulty of the test were related much less closely to the ability level of the examinee on the adaptive test than they were on the conventional test. This suggests that adaptive testing creates a more equivalently reinforcing or encouraging environment for testees of all ability levels. In other words, adaptive testing may offer greater standardization of the psychological environment of testing.

Finally, reactions to the provision of immediate knowledge of results were very favorable. Ninety percent of the examinees who had received KR liked receiving it, and most indicated that receiving KR made testing a more interesting and positive experience. These results, along with the facilitative effects of KR on test performance (Betz and Weiss, 1976) suggest that further research, leading possibly to the wider implementation of immediate KR in testing procedures, is warranted. Thus, continued exploration and wider implementation of new approaches to measurement made possible by computer-assisted testing technology seem critical, especially in light of the current concern with test fairness and bias. Such approaches not only may increase the accuracy of measuring instruments but also may begin to offset the growing public resistance to psychological testing.

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